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The IB programme continuum of international education

Science across the IB continuum





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IB mission statement

The International Baccalaureate aims to develop inquiring, knowledgeable and caring young people who help to create a better and more peaceful world through intercultural understanding and respect.

To this end the organization works with schools, governments and international organizations to develop challenging programmes of international education and rigorous assessment.

These programmes encourage students across the world to become active, compassionate and lifelong learners who understand that other people, with their differences, can also be right.

IB learner profile

The aim of all IB programmes is to develop internationally minded people who, recognizing their common humanity and shared guardianship of the planet, help to create a better and more peaceful world.

IB learners strive to be:

Inquirers	They develop their natural curiosity. They acquire the skills necessary to conduct inquiry and research and show independence in learning. They actively enjoy learning and this love of learning will be sustained throughout their lives.
Knowledgeable	They explore concepts, ideas and issues that have local and global significance. In so doing, they acquire in-depth knowledge and develop understanding across a broad and balanced range of disciplines.
Thinkers	They exercise initiative in applying thinking skills critically and creatively to recognize and approach complex problems, and make reasoned, ethical decisions.
Communicators	They understand and express ideas and information confidently and creatively in more than one language and in a variety of modes of communication. They work effectively and willingly in collaboration with others.
Principled	They act with integrity and honesty, with a strong sense of fairness, justice and respect for the dignity of the individual, groups and communities. They take responsibility for their own actions and the consequences that accompany them.
Open-minded	They understand and appreciate their own cultures and personal histories, and are open to the perspectives, values and traditions of other individuals and communities. They are accustomed to seeking and evaluating a range of points of view, and are willing to grow from the experience.
Caring	They show empathy, compassion and respect towards the needs and feelings of others. They have a personal commitment to service, and act to make a positive difference to the lives of others and to the environment.
Risk-takers	They approach unfamiliar situations and uncertainty with courage and forethought, and have the independence of spirit to explore new roles, ideas and strategies. They are brave and articulate in defending their beliefs.
Balanced	They understand the importance of intellectual, physical and emotional balance to achieve personal well-being for themselves and others.
Reflective	They give thoughtful consideration to their own learning and experience. They are able to assess and understand their strengths and limitations in order to support their learning and personal development.

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About this publication

Science provides an essential contribution to life both within IB World Schools and in society at large. It is a required component in all three IB programmes and is addressed in a developmentally appropriate way within each.

This publication focuses on teaching and learning science across the continuum of IB programmes: the Primary Years Programme (PYP), the Middle Years Programme (MYP) and the Diploma Programme (DP). It highlights the alignment and the differences that exist within and between the three IB programmes. The appendices focus on MYP and DP science through a comparison of science aims and assessment in these two programmes. A diagram is included that may be used to prompt discussions about the teaching and learning of science across all three programmes in IB World Schools.

The contents of this publication will be of interest to all teachers, curriculum developers and school leaders involved in teaching and learning science throughout the school. Schools are encouraged to consider how teaching and learning science within and across IB programmes is aligned and articulated in their school community.

Note: This document is a synthesis of information from existing programme documents and should be used as a companion to the more detailed information in those documents.

Beliefs and values of IB science

Throughout the IB continuum, science is viewed as the exploration of aspects of the natural world and the relationships between them. It is recognized that students' understanding of science continually develops and evolves throughout the IB continuum and beyond. Science within IB programmes leads learners to an appreciation and awareness of the world as it is viewed from a scientific perspective. It encourages curiosity and ingenuity and enables the student to develop an understanding of the world.

The inclusion of science within each of the three IB programmes develops an understanding of the resources of a rapidly changing scientific and technological society, as well as competence in their use. Learners should gain a positive attitude towards science while recognizing that its contribution can have both positive and negative consequences. IB science also involves the development of an appreciation of the scientific contributions of people from different cultures and backgrounds

All IB programmes share common beliefs and values about teaching and learning science that include the following.

- **International dimension:** Students develop an appreciation that science requires open-mindedness and freedom of thought, transcending gender, political, cultural, linguistic, national and religious boundaries.
- **Aesthetic dimension:** Students engage with the complexities, intricacies and beauty of science. IB science arouses their curiosity and heightens their engagement.
- **Ethical dimension:** Students reflect on issues that relate to the ethical, social, economic, political, cultural and environmental implications of the use of science and its application to solving specific problems. Students develop a personal, ethical stance on science-related issues supported by the attributes of the IB learner profile.
- **Inquiry-based:** Students investigate science concepts through purposeful inquiry that is central to scientific investigation and understanding in IB programmes. Students actively construct and test their understanding of the world around them by combining scientific knowledge with reasoning and thinking skills.
- **Learning through investigation:** Students construct meaning through scientific inquiry to design, carry out and reflect on scientific investigations. The scientific process—encouraging hands-on experience, inquiry and critical thinking—enables students to make informed and responsible decisions, not only in science but also in other areas of life.
- **Collaboration:** Students are given opportunities to work individually and collaboratively to develop their understanding of science within and beyond the classroom. They develop safe, responsible and collaborative working practices in practical science sessions.
- **Relevance and authenticity:** Students understand that science is studied in real-world contexts where connections between theory and practice are embedded into a challenging and engaging curriculum.
- **Assessment:** Students' work and performance are assessed through formative and summative assessments. These assessments inform future learning and allow students to demonstrate their understanding and application of scientific concepts.

The IB learner profile provides a strong foundation for, and is integral to, teaching and learning science in IB programmes. It is a primary consideration in the planning stages. Creating opportunities for students to reflect on their development of the learner profile attributes will encourage them to become effective learners and internationally minded students when learning about and through science.

Reflection on scientific knowledge also helps students to develop a sense of responsibility regarding the impact of their actions on themselves, others and their environment. All students should have the opportunity to apply scientific understandings both within and beyond the classroom. Science throughout the IB continuum contributes to the development of students as global citizens who will think critically and creatively when solving problems and making decisions affecting themselves, others and the environment.

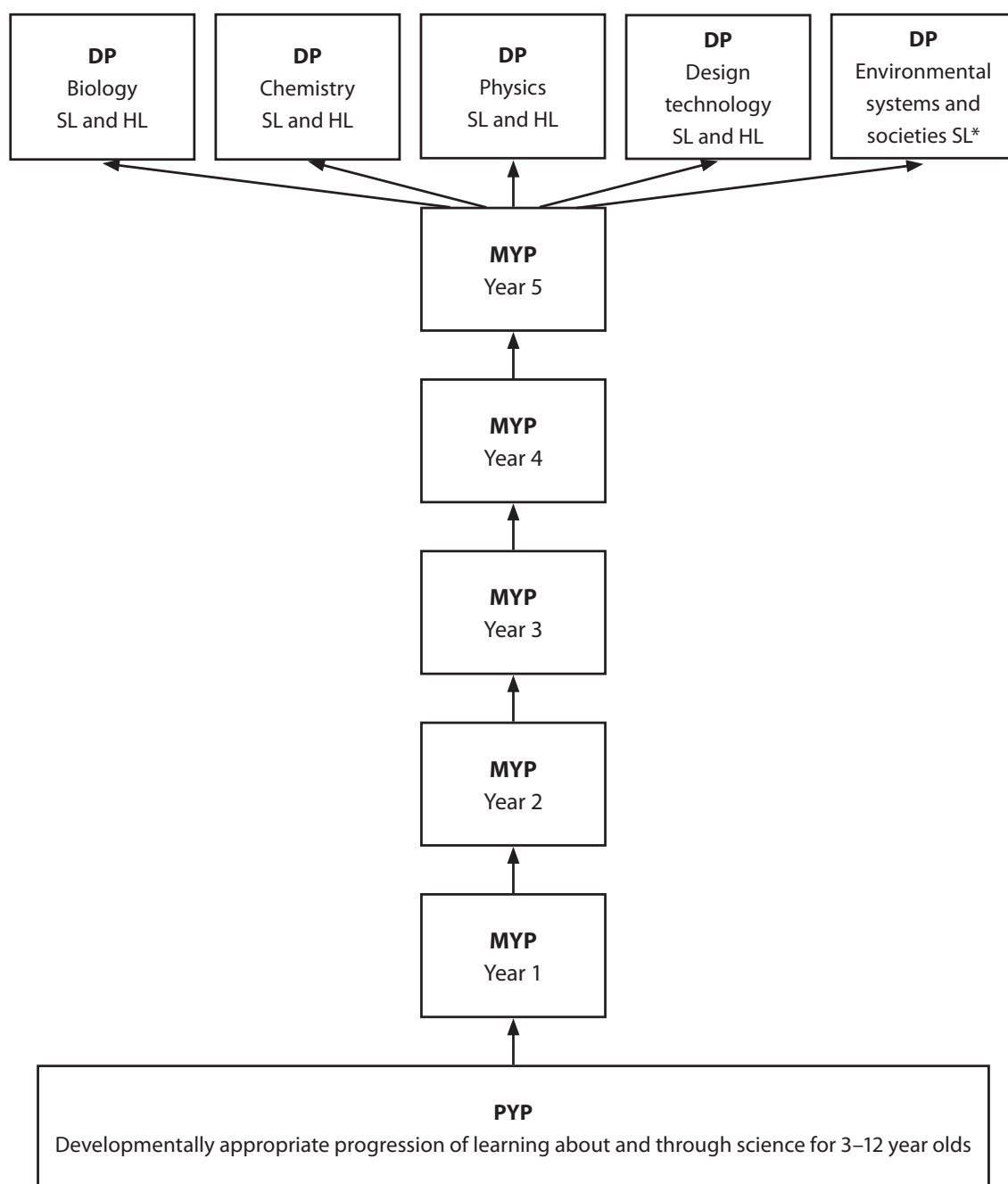
Science in the IB continuum

Science is a required component of all three IB programmes: the PYP, MYP and the DP.

In the PYP, teaching and learning experiences challenge students to be curious, ask questions, explore and interact with the environment physically, socially and intellectually in order to construct meaning and refine their understanding. The use of structured inquiry in the PYP is a precursor to the problem-solving and inquiry-based approach of MYP science, which builds on the science learning that students have experienced during their time in the PYP.

The MYP framework for science reflects the concepts and skills of the presumed knowledge for all of the DP science courses. Students continuing on to the DP will have developed an inquiring and reflective approach to science learning, as well as critical-thinking and problem-solving skills. They will be able to apply and extend these in their choice of DP science courses.

The flowchart below shows the progression of science teaching and learning from the PYP to the MYP and on to the DP.



* groups 3 and 4 interdisciplinary subject

Figure 1
Continuum from PYP to DP science

IB programme models

The importance of science throughout the IB continuum is highlighted in the three programme models below.

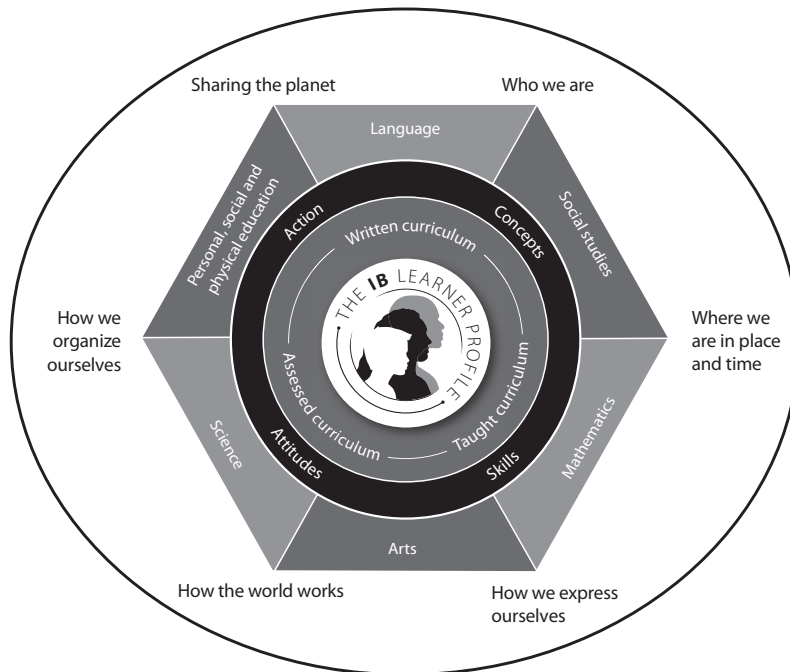


Figure 2
Primary Years Programme

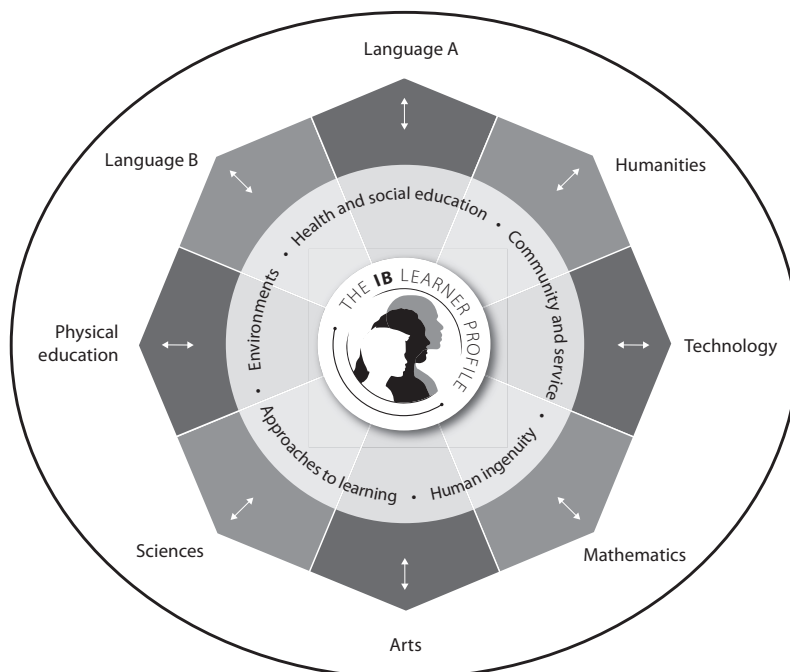


Figure 3
Middle Years Programme

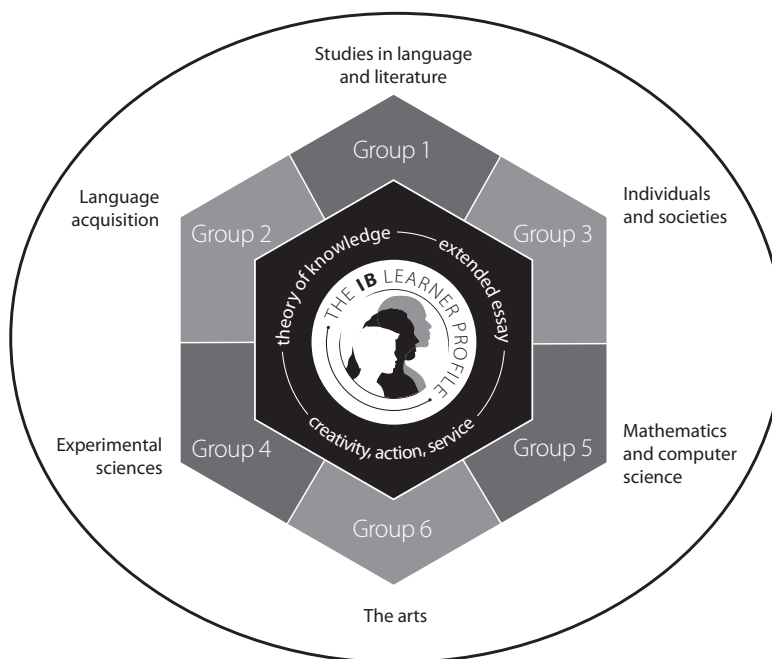


Figure 4
Diploma Programme

Developing the science curriculum

The IB mission statement and the IB learner profile inform teaching, learning and assessment throughout the IB continuum.

IB MISSION STATEMENT

IB LEARNER PROFILE

	PYP	MYP	DP
Nature	Framework	Framework	Prescribed curriculum
	Inclusive	Inclusive	Aimed at preparing students for higher education
Structure	Transdisciplinary units of inquiry	Organized around disciplines with interdisciplinary areas of interaction	Organized around disciplines with theory of knowledge connecting the disciplines
How the programme is assessed	Internal assessment of all aspects of a student's learning	Internal assessment based on subject-specific criteria; schools can opt for external moderation of teachers' internal assessment	External moderation of internally assessed work and external examinations
Learning to learn	Transdisciplinary concepts and skills	Approaches to learning	Theory of knowledge
Learning through experience	Action	Community and service	Creativity, action, service
Language learning	Support for mother-tongue development	Support for mother-tongue/best-language development	Support for mother-tongue development: school supported, self-taught language A1 courses
	School's additional language from age 7	Student's additional language (language B)	Student's additional language (language B)
Culminating experience that synthesizes learning	Exhibition	Personal project	Extended essay

Figure 5

The continuum of IB education

Introduction to science in the PYP

In the PYP the importance of the traditional subject areas is acknowledged. Language, mathematics, social studies, science, arts, and personal, social and physical education are specified as components of the PYP curriculum model. Overall expectations for science, within particular age ranges, are specified in the subject areas annex of *Making the PYP happen: A curriculum framework for international primary education* (November 2009).

It is particularly important for students in the primary years of education to acquire skills in context, and to explore content that is relevant to them and that transcends the boundaries of the traditional subjects. The PYP curriculum is centred on **six transdisciplinary themes** around shared human experiences that are considered essential organizers in the context of the IB's definition of international primary education. These themes are supported by knowledge, concepts and skills from the traditional subject areas but utilize them in ways that transcend the confines of these subjects, thereby contributing to the model of **transdisciplinary teaching and learning**.

PYP transdisciplinary themes

- Who we are
- Where we are in place and time
- How we express ourselves
- How the world works
- How we organize ourselves
- Sharing the planet

Students inquire into, and learn about, these globally significant issues in the context of units of inquiry, each of which addresses a central idea relevant to a particular transdisciplinary theme. These units collectively constitute the school's programme of inquiry. Teachers in IB World Schools that offer the PYP work collaboratively to develop a transdisciplinary programme of inquiry designed to meet the school's needs. Schools explore the possibilities for links between the units taught at each year level, and also across the different age ranges, so that the programme of inquiry is articulated both vertically and horizontally.

In the final year of the PYP, students participate in a culminating inquiry—the PYP exhibition. It is both a transdisciplinary inquiry conducted in a spirit of personal and shared responsibility, as well as a summative assessment activity that is a celebration and rite of passage, symbolic and actual, from the PYP into the middle years of schooling (see the document *PYP Exhibition guidelines* (June 2008)).

The role of science in a transdisciplinary programme

The transdisciplinary themes provide the framework for a highly defined, focused, in-depth programme of inquiry, and as **science** is relevant to all the transdisciplinary themes, all planned science learning should take place within this framework. In return, the science knowledge and the application of that knowledge will enhance inquiries into the central ideas defined by the transdisciplinary themes.

It is worthwhile to note that there will be occasions that present themselves for student-initiated, spontaneous science inquiries that are not directly related to any planned units of inquiry. These are valuable teaching and learning experiences in themselves and they provide teachers and students with the opportunity to apply the pedagogy of the PYP to authentic, of-the-moment situations. Schools that have local and/or national curriculum requirements in science should articulate how best this predetermined knowledge (or skills) can be incorporated into their programme of inquiry to the fullest possible extent. They will need to plan how students can be encouraged to think scientifically, and promote this way of working throughout the curriculum and not just in the programme of inquiry.

The science component of the PYP should be characterized by concepts and skills rather than by content. The PYP **key concepts** promote conceptual development and allow for connections to be made across learning. Schools select the **related science concepts**, derived from the four science strands, that they wish to develop and these can be mapped back to the key concepts. (For examples of related science concepts, see the subject area annex *Making the PYP happen: A curriculum framework for international primary education*).

In addition to the transdisciplinary themes, the **knowledge** component of science in the PYP is explored through four strands.

- **Living things:** The study of the characteristics, systems and behaviours of humans and other animals, and of plants; the interactions and relationships between and among them, and with their environment.
- **Earth and space:** The study of planet Earth and its position in the universe, particularly its relationship with the sun; the natural phenomena and systems that shape the planet and the distinctive features that identify it; the infinite and finite resources of the planet.
- **Materials and matter:** The study of the properties, behaviours and uses of materials, both natural and human-made; the origins of human-made materials and how they are manipulated to suit a purpose.
- **Forces and energy:** The study of energy, its origins, storage and transfer, and the work it can do; the study of forces; the application of scientific understanding through inventions and machines.

A set of **transdisciplinary skills** have been identified that are relevant to the subject areas and also transcend them. The development of these thinking skills, social skills, communication skills, self-management skills and research skills will help students to engage in purposeful inquiry.

The **attitudes**—a defined, essential element of the PYP—and the attributes of the IB learner profile also contribute to students learning to think like scientists, which includes the consideration of social issues related to science.

In the PYP, it is believed that education must extend beyond the intellectual to include not only socially responsible attitudes but also thoughtful and appropriate **action**. There is an expectation that successful inquiry will lead to responsible action, initiated by the student as a result of the learning process. The PYP advocates a cycle of involvement that provides students with opportunities to engage in purposeful and beneficial action through a cycle of choose, act, reflect.

Overall expectations in science

The PYP *Science scope and sequence* (July 2008) identifies the overall expectations considered appropriate in the PYP. It does this by looking at the central ideas included in the sample programme of inquiry published in *Developing a transdisciplinary programme of inquiry* (January 2008) and by identifying the essential understandings and processes being developed within each age range.

These expectations (outlined here) are not a requirement of the programme. However, schools need to be mindful of practice C2:4b in the IB document *Programme standards and practices* (October 2010) that states: "The overall expectations of student achievement in the school's scope and sequence documents are aligned with those expressed in the Primary Years Programme scope and sequence documents." To arrive at such a judgment, and given that the overall expectations in the PYP *Science scope and sequence* are presented as broad generalities, it is recommended that schools undertake a careful consideration of their own scope and sequence document in order to identify the overall expectations in science for their students.

3–5 years

Students will develop their observational skills by using their senses to gather and record information, and they will use their observations to identify simple patterns, make predictions and discuss their ideas. They will explore the way objects and phenomena function, and will recognize basic cause and effect relationships. Students will examine change over varying time periods and know that different variables and conditions may affect change. They will be aware of different perspectives, and they will show care and respect for themselves, other living things and the environment. Students will communicate their ideas or provide explanations using their own scientific experience and vocabulary.

5–7 years

Students will develop their observational skills by using their senses to gather and record information, and they will use their observations to identify patterns, make predictions and refine their ideas. They will explore the way objects and phenomena function, identify parts of a system, and gain an understanding of cause and effect relationships. Students will examine change over varying time periods, and will recognize that more than one variable may affect change. They will be aware of different perspectives and ways of organizing the world, and they will show care and respect for themselves, other living things and the environment. Students will communicate their ideas or provide explanations using their own scientific experience.

7–9 years

Students will develop their observational skills by using their senses and selected observational tools. They will gather and record observed information in a number of ways, and they will reflect on these findings to identify patterns or connections, make predictions, and test and refine their ideas with increasing accuracy. Students will explore the way objects and phenomena function, identify parts of a system, and gain an understanding of increasingly complex cause and effect relationships. They will examine change over time, and will recognize that change may be affected by one or more variables. They will examine how products and tools have been developed through the application of science concepts. They will be aware of different perspectives and ways of organizing the world, and they will be able to consider how these views and customs may have been formulated. Students will consider ethical issues in science-related contexts and use their learning in science to plan thoughtful and realistic action in order to improve their welfare and that of other living things and the environment. Students will communicate their ideas or provide explanations using their own scientific experience and that of others.

9–12 years

Students will develop their observational skills by using their senses and selected observational tools. They will gather and record observed information in a number of ways, and they will reflect on these findings to identify patterns or connections, make predictions, and test and refine their ideas with increasing accuracy. Students will explore the way objects and phenomena function, identify parts of a system, and gain an understanding of increasingly complex cause and effect relationships. They will examine change over time, and they will recognize that change may be affected by one or more variables. Students will reflect on the

impact that the application of science, including advances in technology, has had on themselves, society and the environment. They will be aware of different perspectives and ways of organizing the world, and they will be able to consider how these views and customs may have been formulated. Students will examine ethical and social issues in science-related contexts and express their responses appropriately. They will use their learning in science to plan thoughtful and realistic action in order to improve their welfare and that of other living things and the environment. Students will communicate their ideas or provide explanations using their own scientific experience and that of others.

Introduction to MYP aims and objectives

The MYP curriculum framework consists of eight **subject groups** with prescribed aims and objectives. The subject groups are connected by the areas of interaction, which provide real-world contexts for connecting the content of the subject disciplines.

For each subject group the MYP prescribes a curriculum framework of aims and objectives that students are expected to meet by the completion of the programme. The final objectives of each subject group are usually framed in these terms:

- knowledge
- conceptual understanding
- skills and attitudes.

Schools have the responsibility of structuring their own curriculum in each subject group, using the prescribed curriculum framework of aims and objectives. MYP teachers are expected to work collaboratively, planning the curriculum both vertically and horizontally, and identifying connections within and across subject groups.

The **areas of interaction** give the MYP its distinctive core. The areas are common to all subject groups and they provide the context through which the curriculum content interacts with the real world. Through these contexts students should become aware of the relevance of their learning to real-world issues, and should come to see knowledge, concepts, skills and attitudes as an interrelated whole.

MYP areas of interaction

- Approaches to learning
- Community and service
- Human ingenuity
- Environments
- Health and social education

As well as providing a context for student inquiry in each subject group, the areas of interaction have an integrative function. They connect the learning from different subjects and promote the exploration of significant interdisciplinary teaching and learning opportunities.

Interdisciplinary learning in the MYP is the process by which students come to understand bodies of knowledge and modes of thinking from two or more disciplines or subject groups and integrate them to create a new understanding. It is a central feature of the MYP curriculum and should be visible in teachers' units of work, student work and assessment criteria. Interdisciplinary learning seeks to promote interdisciplinary understanding. Students demonstrate interdisciplinary understanding of a particular topic when they bring together concepts, methods or forms of communication from two or more disciplines or established areas of expertise to explain a phenomenon, solve a problem, create a product or raise a new question in ways that would have been unlikely through single disciplinary means.

As with the PYP, schools must plan collaboratively—both vertically and horizontally—throughout the five years of the MYP to explore the links between the discipline-based and interdisciplinary units taught at each grade level and across the grades.

Through the areas of interaction, the subject groups and interdisciplinary opportunities for teaching and learning, the MYP presents knowledge as an integrated whole, emphasizing the acquisition of skills and self-awareness, and the development of personal values. As a result, students are expected to develop an awareness of the interconnections and complexities of issues and thus gain an enduring and deeper understanding.

Introduction to MYP sciences

IB World Schools can either offer discrete science courses (for example, biology, chemistry, physics) or a sciences course encompassing elements of the different science subjects. Schools are responsible for developing the courses and structuring the science curriculum in accordance with stated **aims and objectives** that describe what is expected of students by the end of the programme. The circumstances specific to individual schools and their local curricular requirements will determine how schools structure their curriculum and the courses that they can offer. However, schools must ensure that the curriculums and the courses developed provide students with enough opportunities to effectively meet the final aims and objectives of the subject group by the end of the programme.

There is no external **assessment** provided by the IB for the MYP and therefore no formal externally set or marked examinations. All assessment in the MYP is carried out by teachers in participating schools and relies on their professional expertise in making qualitative judgments, as they do every day in the classroom. Instead, MYP schools must follow a criterion-related approach. Students' work is assessed against subject-related assessment criteria and not against the work of other students. The six assessment criteria for MYP sciences are directly related to the course objectives.

Units of work are designed to develop and enhance conceptual understanding. These may be planned and delivered in a disciplinary or interdisciplinary manner. The MYP **areas of interaction** provide the contexts for learning science through inquiry. They connect learning in sciences with the world beyond the classroom and also connect learning in sciences with other subjects. The areas of interaction provide the opportunity for students to achieve deeper levels of understanding.

The **vision** of MYP sciences is to contribute to the development of students as inquirers, scientifically literate, caring and responsible individuals who will think critically and creatively when solving problems and making decisions about aspects affecting themselves, others and their social and natural environments.

MYP sciences and their methods of investigation offer a way of learning that contributes to the development of an **analytical and critical way of thinking**. **Inquiry** is at the heart of MYP sciences and aims to support students' understanding of sciences by providing them with opportunities to independently investigate relevant issues through both research and experimentation.

Learning science relies on understanding and using the **language** of science, which involves more than simply learning technical scientific terminology. MYP sciences aim for students to become competent and confident when accessing, using and **communicating** scientific information. Students are expected to use scientific language correctly and select appropriate communication formats for oral and written communication. Students should learn how to **appreciate, respect and acknowledge the ideas and work of others**.

MYP sciences aim to provide students with the opportunity to show their **understanding** of the main concepts and processes of science, by applying these to solve problems in familiar and unfamiliar situations. Students should demonstrate critical-thinking skills to analyse and evaluate information in order to make informed judgments in a variety of contexts.

The MYP sciences must have curriculums that are relevant to the interests of students, providing them with opportunities to explore the connections between **science and everyday life**. It is anticipated that students will become interested in and engaged with the role of science in the world. Through the investigation of

real-life examples of the application of science, the “one world” objective allows students to gain insight into the tensions and dependencies that exist between science and societal, environmental and ethical factors.

Students should further **develop their sense of responsibility** as individuals towards the natural, built and virtual environment. Their engagement, interest and enjoyment in science should foster a positive response to science and contribute to the development of opinion-forming, decision-making and **ethical-reasoning** skills.

Introduction to DP science

The DP is structured around the shape of a hexagon, with **six subject groups** or academic areas enclosing a central core. Students select six subjects—one from each academic area—and also study or participate in the three areas of the core.

Diploma Programme core areas

- Extended essay
- Theory of knowledge (TOK)
- Creativity, action, service (CAS)

For each of the subjects in the hexagon, the syllabus and assessment model are prescribed in great detail.

The DP is a pre-university course of study leading to examinations; it is designed as a comprehensive two-year curriculum that allows its graduates to fulfill the requirements of university entrance to universities worldwide.

Through studying any of the group 4 subjects, students should become aware of how scientists work and communicate with each other. While the “scientific method” may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that distinguishes the group 4 subjects from other disciplines and characterizes each of the subjects within group 4.

There is no one scientific method for gaining knowledge of, or finding explanations for, the behaviour of the natural world. Science works through a variety of approaches to produce these explanations, but they all rely on data from observations and experiments and have a common underpinning rigour. The explanation may be in the form of a theory, sometimes requiring a model that contains elements not directly observable. Producing these explanations often requires an imaginative, creative leap. All of these explanations require an understanding of the limitations of data, and the extent and limitations of our knowledge. Science requires freedom of thought and open-mindedness.

Science itself is an international endeavour—the exchange of information and ideas across national boundaries has been essential to the progress of science. The scientific method in its widest sense, with its emphasis on peer review, open-mindedness and freedom of thought, transcends politics, religion and nationality.

Increasingly there is a recognition that many scientific problems—from climate change to AIDS—are international in nature, and this has led to a global approach to research in many areas.

The group 4 project is an interdisciplinary activity in which all Diploma Programme science students must participate. It mirrors the work of real scientists by encouraging collaboration between schools across the regions. The emphasis is on the processes involved in scientific investigation rather than the products of such investigation.

In line with the IB mission statement, group 4 students need to be aware of the moral responsibility of scientists to ensure that scientific knowledge and data are available to all countries on an equitable basis and that they have the scientific capacity to use this for developing sustainable societies.

The recommended teaching times for all Diploma Programme courses are 150 hours at SL and 240 hours at HL. Students are required to spend 40 hours at SL and 60 hours at HL on practical activities (excluding time spent writing up work).

The different types of experimental work that a student may engage in also serve other purposes, including:

- illustrating, teaching and reinforcing theoretical concepts
- developing an appreciation of the essential hands-on nature of scientific work
- promoting an understanding of the benefits and limitations of scientific methodology.

Assessment of student learning in science

Assessment at the school reflects IB assessment philosophy.

Standard C4, *IB Programme standards and practices* (October 2010)

Assessment in all three programmes supports and encourages effective teaching and learning of science. There are key principles of assessment that are common to all three programmes (see *Towards a continuum of international education* (September 2008)).

- Assessment is integral to planning, teaching and learning.
- The assessment system and assessment practices are made clear to students and parents.
- There is a balance between formative and summative assessment.
- Opportunities for peer- and self-assessment are planned for.
- Opportunities for students to reflect on their own learning are planned for.
- Students' current knowledge and previous experience are assessed before embarking on new learning.
- Students are provided with feedback as a basis for future learning.
- Reporting to parents is meaningful.
- Assessment data is analysed to provide information about the teaching and learning, and the needs of individual students.
- Assessment is used to evaluate the effectiveness of the curriculum.

The *IB Programme standards and practices* document (practice C4:1) states that: "Assessment at the school aligns with the requirements of the programme(s)." Although the philosophy of assessment and the IB assessment principles apply to all three programmes, there are significant differences in the assessment systems, designed to meet the needs of students at particular ages and stages of their development. This is recognized in practice C1, where the requirements of each programme reflect the developmental differences of students.

PYP assessment

The prime objective of assessment in the PYP is to provide feedback on students' learning. In the PYP all assessment is internal and is carried out collaboratively with other teachers in the school—and, at times, with students themselves. The IB provides overall expectations for each subject area as set out in the subject-specific scope and sequence documents. The IB does not provide external moderation or examinations for students in the PYP.

Teachers employ techniques for gathering evidence of each student's understanding that take into account the diverse, complicated and sophisticated ways that individual students use to make sense of their experiences. The assessment strategies and tools proposed by the PYP—rubrics, exemplars, anecdotal records, checklists, continuums, portfolios of work—are designed to accommodate a variety of intelligences and ways of knowing. Where possible, they provide an effective means of recording students' responses and performances in the context of authentic, real-life situations.

Successful learning of science has taken place when students can demonstrate and apply their understanding of science concepts that they have encountered and reflected on during a unit of inquiry. They should be able to frame authentic, open-ended questions worthy of sustained research. As they conduct their inquiries, they should be able to:

- collect information accurately
- analyse information
- offer explanations
- refine their understanding.

Students should be able to identify the possible causes of a problem, choose and test a solution, and reflect on appropriate action to be taken. Their ability and willingness to take action would demonstrate their understanding of the responsibilities that go along with learning.

MYP assessment

Assessment in the MYP is criterion-related. There are six science assessment criteria corresponding to the MYP science objectives, which are published in the *MYP Sciences guide* (February and May 2010). This assessment is carried out by teachers in the school, relying on their professional expertise.

Teachers use a range of formative and summative assessment strategies to provide feedback on the performance of students, who are required to demonstrate their understanding of science.

There is no external assessment provided by the IB for the MYP and therefore no formal, externally set or marked examinations. External validation of student grades is available through external moderation; however, moderation is optional. The IB moderation and monitoring of assessment services ensure that the final judgments made by teachers all conform to an agreed scale of measurement on common criteria.

DP assessment

In group 4, the subjects physics, chemistry and biology have common aims and there is a single model of assessment for all three. This consists of practical work weighted at 24%, undertaken throughout the course, and written examinations weighted at 76%, taken at the end of the course.

As in the MYP, DP students are assessed in practical work using performance-related assessment criteria. The assessment is undertaken internally by the teacher and externally moderated by the IB. For internal assessment there are three assessment criteria to assess practical investigations:

- design
- data collection and processing
- conclusion and evaluation.

Two pieces of work are assessed for each criterion. The criterion “manipulative skills” is used summatively to assess a student’s hands-on practical skills during the course and the criterion “personal skills” is used to assess a student’s participation in the group 4 project.

The summative assessment that takes place at the end of the course is in the form of three written examination papers:

- paper 1—a multiple-choice question paper
- paper 2—a mixture of short-answer questions and extended-response questions
- paper 3—examining performance in the chosen topic options.

A student's mark for the practical work is added to the marks for each examination paper to give a percentage (using their respective weightings). This percentage is then converted into a grade between 1 and 7 using the subject grade boundaries, with 1 being the lowest grade and 7 the highest grade.

The IB *Programme standards and practices* document (practice C4:2) states that: "The school communicates its assessment philosophy, policy and procedures to the school community." It is a requirement that every IB World School has an assessment policy that reflects the school's philosophy and position on assessment. It is important for all teachers to be aware of the school's assessment policy and to reflect on how it applies to teaching and learning in their own subject area.

Language in science across the IB continuum

The language of science is a specialized discourse where vocabulary may have meanings specific to the discipline. These meanings may be different from other uses of the same vocabulary in the contexts of other disciplines and ordinary speech. Furthermore, the linguistic genres used in scientific discourse are academic and are not necessarily intuitively understood, particularly by those who may be learning in a language other than their mother tongue.

A school language policy should state clearly how students will be helped to acquire the language required for success in science and might include information related to the following aspects.

- The belief that “all teachers are language teachers”
- Teacher professional development
- A glossary of terms
- Samples of common linguistic genres
- Strategies for scaffolding language and learning
- Role of mother tongue and background knowledge

Further information with regard to language and learning can be found in these two documents on the **Language and learning** page of the online curriculum centre (OCC).

- *Learning in a language other than a mother tongue in IB programmes* (April 2008)
- *Guidelines for developing a school language policy* (April 2008)

Transition strategies

Moving from the PYP to the MYP

It is important to ensure that there is a smooth transition process for students as they move from the PYP to the MYP. If the structure of the school allows, there should be opportunities for:

- discussion between teachers of the two programmes, in particular teachers working in the final year of the PYP and the first year of MYP
- discussion about the similarities and differences between teaching and learning science in a transdisciplinary programme versus an interdisciplinary programme, and how one can support the other
- sharing examples of assessment strategies and tools used in the PYP that can be built upon in the MYP
- sharing examples of how, in the PYP, learning about and through science takes place within the transdisciplinary programme of inquiry. The programme of inquiry will help MYP teachers to understand how different units of inquiry provide opportunities for the teaching and learning of science
- raising PYP teachers' awareness about the nature of teaching and learning in the MYP and, in particular, the objectives for science learning in the first year of the programme.

All other information regarding science is available through the programme-specific publications, available on the online curriculum centre (OCC) at <http://occ.ibo.org>.

Moving from the MYP to the DP

There are a number of strategies teachers can use in developing a smooth transition between MYP and DP science courses. These include:

- ongoing professional development that emphasizes the continuity, aims and objectives of the two programmes
- promoting the integration of the IB learner profile when planning the science curriculum and its implementation in the classroom
- facilitating vertical planning sessions between science teachers in the two programmes
- developing an understanding and consistent use of a common set of key terms, notation and formulae that are applicable to both programmes
- facilitating collaborative planning opportunities for teachers to share their professional practices
- encouraging teachers to reflect on their own professional practices in terms of science across the continuum
- monitoring student learning in science through a variety of ongoing assessments
- reinforcing and developing students' understanding of previously learned science concepts

- ensuring access to and being familiar with the guides and teacher support material provided for each programme (all available from the OCC)
- encouraging the use of collaborative teaching across the programme continuum, and engagement with collaborative learning environments, including the forums on the OCC
- preparing students to develop effective strategies for external examinations as well as inquiry-based learning across all the science courses
- providing students with the opportunity to explore problems that incorporate several areas of science
- providing students with the opportunity to solve problems using science concepts in unfamiliar situations
- providing opportunities for interaction between students of both programmes to share their experiences in science.

Summary: The way ahead

The main focus of this publication has been to raise awareness of the nature of teaching and learning science in the three IB programmes. Whether your school offers one, two or three IB programmes, all schools offer a continuum of learning and it is hoped that the contents of this publication will help schools to align and articulate the expectations for teaching and learning science throughout the school.

The main approach to teaching and learning sciences in the PYP is through structured inquiry in the context of transdisciplinary units of inquiry. PYP students are encouraged to learn about and through science by formulating their own questions and finding the answers to those questions, including through research and experimentation. In turn, students construct meaning and create models of how the world works through the acquisition of scientific knowledge and skills, and the development of conceptual understanding. Opportunities for the demonstration of constructive attitudes and the taking of responsible action are also a feature of science learning in the PYP.

Scientific inquiry is central to teaching and learning science in the MYP, which builds on the experiences in science learning that students have gained during their time in the PYP. It enables students to develop a way of thinking and a set of skills and processes that, while allowing them to acquire knowledge and understanding, equips them with the capabilities to tackle with confidence the group 4 subjects they choose in the DP. MYP science objectives and assessment criteria are aligned with the DP group 4 objectives and internal assessment criteria and, as such, should support the smooth transition from the middle years to pre-university studies. In turn, the DP science subjects prepare students both for the challenge of specific post-secondary education in science and for producing citizens able to make informed decisions about scientific issues.

There is much to celebrate about teaching and learning science within the continuum of the three IB programmes. Teachers are encouraged to collaborate and share their effective practices within their schools and the wider IB community. It is hoped that this publication will be a catalyst for strengthening the alignment and articulation of IB science across the whole school.

The aims of MYP sciences and Diploma Programme group 4 subjects

The MYP sciences and the group 4 science subjects in the Diploma Programme have 10 stated aims in their respective guides. The following table shows the correspondence between the stated aims of the two programmes (the numbers 1 to 10 refer to the numbers of each aim in the respective curriculum guide).

Six of the aims, although not identical, reflect a direct correspondence between the two programmes. Of these, aim 5 in the Diploma Programme corresponds to aims 10 and 3 in the MYP.

The four remaining aims in the Diploma Programme, and three in the MYP, do not have any common features.

MYP sciences	Diploma Programme group 4
<p>The aims of any MYP subject and of the personal project state in a general way what the teacher may expect to teach or do, and what the student may expect to experience or learn. In addition, they suggest how the student may be changed by the learning experience.</p> <p>The aims of the teaching and study of MYP sciences are to encourage and enable students to:</p>	<p>Through studying any of the group 4 subjects, students should become aware of how scientists work and communicate with each other. While the “scientific method” may take on a wide variety of forms, it is the emphasis on a practical approach through experimental work that distinguishes the group 4 subjects from other disciplines and characterizes each of the subjects within group 4. It is in this context that all the Diploma Programme experimental science courses should aim to:</p>
1. develop curiosity, interest and enjoyment towards science and its methods of inquiry	1. provide opportunities for scientific study and creativity within a global context that will stimulate and challenge students
2. acquire scientific knowledge and understanding	2. provide a body of knowledge, methods and techniques that characterize science and technology
3. communicate scientific ideas, arguments and practical experiences effectively in a variety of ways	5. engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
4. develop experimental and investigative skills to design and carry out scientific investigations and to evaluate evidence to draw a conclusion	6. develop experimental and investigative scientific skills
5. develop critical, creative and inquiring minds that pose questions, solve problems, construct explanations, judge arguments and make informed decisions in scientific and other contexts	
6. develop awareness of the possibilities and limitations of science and appreciate that scientific knowledge is evolving through collaborative activity locally and internationally	9. develop an appreciation of the possibilities and limitations associated with science and scientists

MYP sciences	Diploma Programme group 4
7. appreciate the relationship between science and technology and their role in society	
8. develop awareness of the moral, ethical, social, economic, political, cultural and environmental implications of the practice and use of science and technology	8. raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology
9. observe safety rules and practices to ensure a safe working environment during scientific activities	
10. engender an awareness of the need for, and the value of, effective collaboration during scientific activities.	5. engender an awareness of the need for, and the value of, effective collaboration and communication during scientific activities
	3. enable students to apply and use a body of knowledge, methods and techniques that characterize science and technology
	4. develop an ability to analyse, evaluate and synthesize scientific information
	7. develop and apply the students' information and communication technology skills in the study of science
	10. encourage an understanding of the relationships between scientific disciplines and the overarching nature of the scientific method.

Note: The curriculum review teams for the MYP sciences and the DP group 4 reviews, working closely together on the next curriculum reviews, will reflect on these correspondences and align the aims more closely, where desirable, while respecting the pedagogy of both programmes.

MYP and DP science assessment criteria

MYP assessment

There is no external assessment within the MYP; this means that the MYP does not provide externally set examinations or tests. All assessment in the MYP is internal; this means it is carried out by teachers who follow a criterion-related approach. It is expected that students will experience both ongoing, formative assessment (with appropriate, timely feedback) and summative assessment at the end of their course.

MYP sciences prescribe a minimum number of assessment tasks for IB World Schools that want their assessment validated by the IB.

- A scientific investigation
- An end of unit/end of term test
- A piece of writing, 700–1,200 words in length

For schools not seeking validation there are no prescribed assessment tasks but it is expected that a variety of types of activity will be used (for example, projects, exhibitions, oral presentations, performances, demonstrations, written papers and essays).

DP group 4 assessment

All group 4 subjects, with the exception of design technology, have a common assessment model.

Internal assessment consists of:

- an interdisciplinary project
- a mixture of short- and long-term investigations.

It is expected that practical work will underpin theoretical study throughout the course. Appropriate skills will be developed and assessed towards the end of the course.

External assessment consists of three written papers, all taken at the end of the course.

Assessment criteria: A comparison

The MYP sciences assessment criteria apply to all MYP science subjects, whereas the DP group 4 assessment criteria apply only to internal assessment, which is limited to 24% of the total assessment.

In comparing assessment criteria across the two programmes, it is clear that there is some correspondence between them. However, it is equally clear that some of the MYP assessment criteria have a correspondence with other aspects of the DP group 4 sciences (whether assessment-related or otherwise).

MYP	DP		
Internal assessment criteria and other aspects of group 4 sciences			
Criterion A: One world	Requires students to discuss and evaluate the moral, social, economic, political, cultural and environmental implications of the use of science and its applications in solving specific problems or issues.	Aim 8	Raise awareness of the moral, ethical, social, economic and environmental implications of using science and technology.
	Students are expected to become aware that science is a global endeavour and its developments and applications can have consequences for our lives.	Aim 9	Develop an appreciation of the possibilities and limitations associated with science and scientists.
		International dimension—this is brought out in the international dimension of the current group 4 guides and is explored in more detail in special teacher notes attached to relevant assessment statements.	
Criterion B: Communication in science	Requires students to use appropriate scientific language, a range of communication modes and the most appropriate communication formats to effectively communicate ideas, theories and findings in science.	These skills are picked up, used and developed further in:	practical work and internal assessment
			extended essay
			group 4 project action phase
		group 4 project final presentation	written papers, especially biology and design technology extended answer/essay questions. In essay questions in biology, marks are awarded for the quality of written communication.

MYP	DP	
Science assessment criteria		Internal assessment criteria and other aspects of group 4 sciences
<p>Criterion C: Knowledge and understanding of science</p>	<p>Requires students to solve problems in familiar and unfamiliar situations. Students are expected to analyse and evaluate scientific information to make judgments supported by scientific understanding.</p>	Written papers
	<p>Suitable assessment tasks include: tests, exams, case studies, written responses (and other assignments that combine a range of questions of different complexity and allow students to analyse and evaluate information).</p>	<p>Practical work and internal assessment: Data collection and processing: Aspect 2—processing raw data Conclusion and evaluation: Aspect 1—states a conclusion based on an interpretation of the data</p>
<p>Criterion D: Scientific inquiry</p>	<p>Requires students to develop intellectual and practical skills to design and carry out scientific investigations independently and to evaluate the experimental design.</p>	Practical work and internal assessment:
	<p>Students state a focused problem or research question to be tested by a scientific investigation.</p>	Design
	<p>Students formulate a testable hypothesis and explain it using scientific reasoning.</p>	<p>Aspect 1—defining the problem and selecting variables</p>
	<p>Students design a scientific investigation that includes variables and controls, materials and equipment needed, a method to be followed and the way in which the data is to be collected and processed. Students are expected to identify and manipulate variables.</p>	<p>Construct, analyse and evaluate: hypotheses, research questions and predictions Tested in written papers</p> <p>Aspect 1—defining the problem and selecting variables Aspect 2—controlling variables</p>

MYP	DP	
Science assessment criteria		Internal assessment criteria and other aspects of group 4 sciences
Criterion E: Processing data	Students design an appropriate investigation.	Design Aspect 3—developing a method for collecting data
	Students evaluate the validity and reliability of the method.	Conclusion and evaluation Aspect 2—evaluating procedures Aspect 3—improving the investigation
	Requires students to collect, process and interpret sufficient data to draw conclusions. Collect and record data. Organize and transform data using numerical calculations and visual forms (tables, graphs and charts). Analyse and interpret data. Draw conclusions consistent with data.	Data collection and processing: Aspect 1—recording raw data Aspect 2—processing raw data Aspect 3—presenting processed data
		Conclusion and evaluation: Aspect 1—concluding
Criterion F: Attitudes in science	Requires students to develop safe, responsible and collaborative working practices. Encourages safety, respect and collaboration.	Practical work and internal assessment
	Students carry out scientific investigations, working safely and using material and equipment skillfully. Students work effectively as individuals and as members of a group collaborating with others.	Manipulative skills Summative assessment: Aspect 1—following instructions Aspect 2—carrying out techniques Aspect 3—working safely
	Students work responsibly with regards to the living and non-living environment.	Personal skills Assessed in the group 4 project Aspect 2—working within a team

Conclusion

MYP sciences and DP group 4 experimental science aim to make students aware of the role of science in the world. Both programmes encourage students to gain a better understanding of how science and its applications can have societal, environmental, moral and ethical implications.

The development of communication skills and the understanding of the language of science are fundamental for understanding and learning science; this fact is acknowledged by both MYP science and DP group 4 experimental sciences. While in the MYP communication is present as one of the six assessment criteria for sciences, in the DP the expectation is present in the examination papers, essay questions and the group 4 project.

Both programmes place an important emphasis on the use of practical work as a means of enabling students to develop the intellectual and practical skills associated with scientific inquiry.

There are many similarities between the MYP sciences assessment criteria and the internal assessment criteria at diploma level.

- There is a close correspondence between MYP assessment criterion D (scientific inquiry) and criterion D (design) of group 4 assessment.
- There are similarities between MYP assessment criterion E (processing data) and the criterion DCP (data collection and processing) of group 4 assessment.
- While at diploma level the evaluation and conclusion are parts of one assessment criterion (conclusion and evaluation), these aspects are part of criteria D and E in MYP sciences.
- There are some similarities between both programmes in the development of practical manipulative skills and personal skills (attitudes in science, manipulative skills and personal skills).
- Knowledge and understanding of sciences is present in both programmes as an explicit assessment criterion to be used primarily in tests in the MYP. Students' knowledge and understanding of science is assessed through the various group 4 written papers and the group 4 project in group 4 experimental sciences.

Future curriculum reviews will work closely together to further align and make more explicit these overlapping and common features of both MYP sciences and DP group 4 science. In particular, the emphasis on communication in the MYP needs to be made more explicit in the diploma level science courses.

Facilitating transition between IB programmes

The diagram below is taken from *Towards a continuum of international education* (September 2008). This diagram outlines the key features of the three IB programmes. The questions in the boxes to the right of the diagram are intended as prompts to stimulate dialogue and help to foster understanding about teaching and learning science in IB World Schools offering two or more IB programmes.

